Research Summary
Scheduler™ Evaluation of Water Stress in Tomatoes at BeefSteak Tomato Growers Quincy, Flordia April-June, 1986

by

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A couple of areas of interest.

① We failed to establish an over-watered threshold

② We still do not understand the water use / yield / cost relationship; will we get this from some other experiment

Good report.

Steve

Research Purpose

The purpose of the experiment at BeefSteak Tomato Growers was twofold: first, to evaluate whether or not the Scheduler^{TM} can be effectively used to detect moisture stress in tomatoes and secondly, to determine whether or not the current form of Standard Oil's stress index is appropriate for tomato plants. + establish yield/water use/CWSI relationships.

Experiment Site

This experiment was conducted at the BeefSteak Farm, located in Quincy, Florida. The experiment was conducted on four beds of drip-irrigated tomatoes. Four irrigation treatments were applied. Treatment one consisted of the normal irrigation amounts (between 2 and 4 1/2 hours of irrigation per day, depending on the stage of growth). Treatment two consisted of irrigation amounts between 0 and 3 hours per day. Treatment 3 ranged between 0 and 2 hours of irrigation per day. Treatment 4 was identical to treatment 3 until late in the season, when it was converted to a dryland treatment.

Scheduler^{TM} data was collected by Kurt Plum. Data were collected whenever the sunlight was sufficiently bright (above about 50% full sunlight). No data were collected on rainy or very overcast days. The data which the Scheduler^{TM} collects are air temperature, crop temperature, relative humidity and sunlight intensity. These parameters are used to calculate a crop water stress index (CWSI). A second index, which was not programmed into the instrument which Kurt used, was also calculated at the end of the season. This index is known as the temperature stress index (TSI). The TSI compares stress levels on treatment 1 (assumed to be non-stressed) with treatments two, three and four. Canopy heights of each treatment were also measured periodically.

In the early portion of the season , canopy temperatures were measured by positioning the infrared thermometer (IRT) about 1 ft above the plants, pointed down the center of the row. The IRT was pointed at the top of plants approximately 5 ft away. There was probably some bias introduced by the large amounts of bare soil between plants and between rows (percent ground cover was only about 10-20 %), but experimentation showed that temperature differences between well irrigated and stressed plants were still detectable. Differences as great as 10 F were detectable at these early stages. As the season progressed, the IRT was still pointed down the row. This was done for two reasons. First, the treatment being considered consisted of a single row (or bed). Second, the cultural practices at Beefsteak involved the frequent placing of wooden stakes to tie the tomato branches to, making it impossible to make canopy temperature readings across a row in the first half of the season. The staking practice also created a problem looking down the row. This problem was solved by placing the stakes on either side of the plants (instead of in a straight line) in the areas in which canopy temperatures were measured.

Results and Discussion

Detailed analysis of the CWSI data showed that the CWSI results were not reliable nor consistent in their behavior. This was surprising since the canopy temperature patterns seemed well behaved. The data show that it was the air temperature and relative humidity patterns which were biased . This is not the fault of the operator, but rather of the design of the instrument. The design of the prototype used in this experiment made it necessary for the operator to place the cpu (computer) unit on the ground. Unfortunately,. the air temperature and humidity sensors are also located in the cpu unit. Consequently, there are strong interactions between soil temperatures, plastic temperatures, and irrigation

treatment. These interactions negate the CWSI index. Consequently, no conclusions can be reached concerning the untility of CWSI on tomato plants. In order to study CWSI on tomato plants, it is essential that the new instrument design, where all sensors are located in a single sensing head, be used.

Fortunately, the TSI index could also be calculated. This index requires the assumption that a non-water stressed area exists for reference purposes. For this analysis, treatment 1 was assumed non-stressed. By definition, TSI for treatment 1 is always zero. The TSI analysis indicates that significant water stress levels had begun developing by April 29 (Figure 1). Interestingly, no visual symptoms of water stress were noted by Kurt until June 6. TSI values for treatment 3 and 4 were not statistically different. Treatment 2 had significantly smaller TSI values than treatments 3 and 4 , but were significantly higher than treatment 1.

The yield data (figure 2) shows that yields were significantly affected by the irrigation treatments. The effects of the treatments potentially could have been stronger, but the experimental design used allowed for the possibility of plants on treatments 2-4 tapping some of the water from treatment 1 plants. In the future, a design should be used which prevents this possibility. Treatment effects were also clearly evident in the quality of the fruit (as judged by size). The quality rankings used were: rank 1--5x6 fruit, rank 2- 6x6 fruit, rank 3 -6x7 fruit, and rank 4--7x7 fruit.

Yields were 13.9, 12.2, 9.1 and 5.9 lbs/plant for treatments 1 through 4, respectively. In terms of quality, the percentage of low quality fruit increased as TSI increased (figure 3). Canopy height decreased with increasing stress (figure 4).

From a managment viewpoint, the question can now be asked, could the TSI index have been used to predict yield losses? Figure 5 shows that TSI was strongly related to the yield per box for each treatment. This is the strongest evidence to date that Scheduler^{TM} can be used for managing the stress status of tomatoes. Care should be taken in using figure 5. Data were not collected on a daily basis (as they should be for TSI calculations). Consequently, the observed cumulative TSI values are smaller than they should be (as indicated by the flat spots in figure 1). Since other studies have shown a strong correlation between CWSI and TSI, it is probable that a future study will demonstrate that CWSI is also an effective index to use. CWSI has the advantage that the assumption of a well-watered crop does not have to be made.

Recommendations

On the basis of these results, I recommend that another study be conducted relating CWSI to irrigation requirements in tomatoes. In order for this study to be valid, however, it will be essential that the new version of the instrument be used.

Suggestions for Additional Applications of Scheduler^{tm}

Two suggestions were made for additional uses of Scheduler^{tm} :

1. Equipment maintence. John Schmidt indicated that the infrared thermometer and graphics capability of the Scheduler^{tm} could be used to provide a record of the temperature behavior of machinery. One example he gave was of a motor which remained over-heated for too long during the June harvest. The result was a $3000 replacement cost for the motor plus labor costs for installation. Insuring that tractor motors are not running too hot (or hotter than normal) could result in increased motor life, as well as reduced repair costs.

2. Characterizing the soil environment for planting activities. Soil temperature is a function of the amount of moisture in the soil, air temperature, and the intensity of sunlight and windspeed. Experience has shown that if new tomato plants are transplanted in a soil that is too hot, then high plant mortality rates occur. John identified one tomato farm in Georgia this year that planted when the soil was too hot. Virtually all the plants died, necessitating a re-planting. Scheduler^{tm} could be used to measure soil temperatures and provide warnings to an operator that soil temperatures were approaching an unsafe zone. The result would be a suspension of planting activities until temperatures decreased to acceptable levels, thus preventing unnecessary re-planting expenses.

ACKNOWLEDGMENTS

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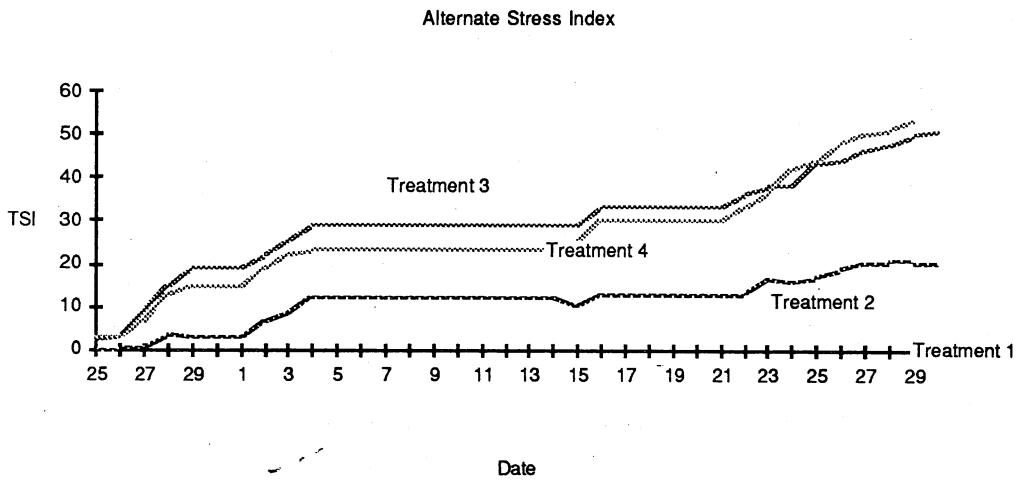
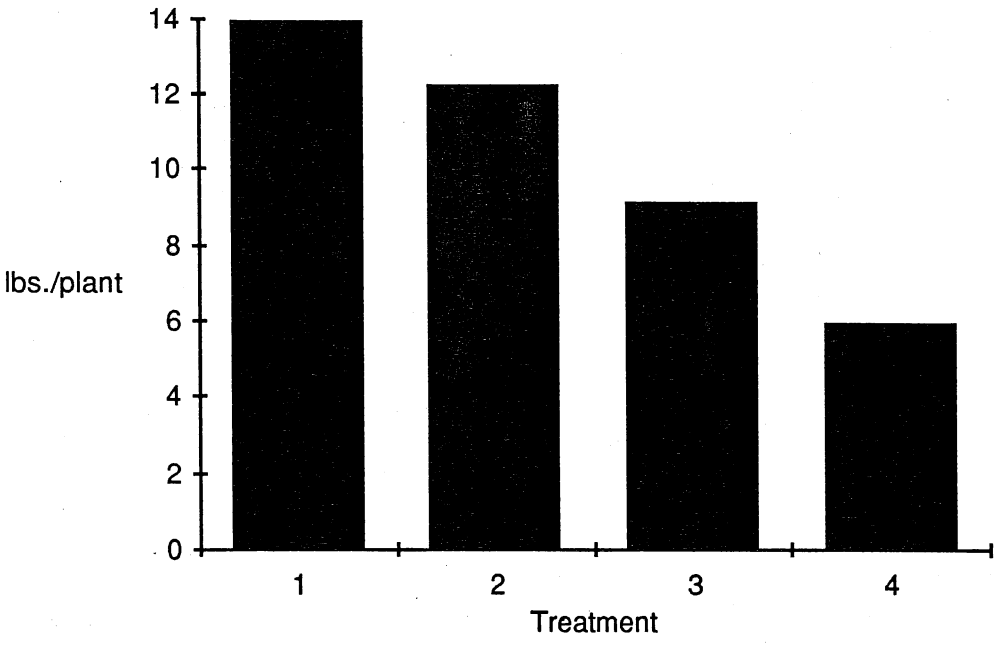
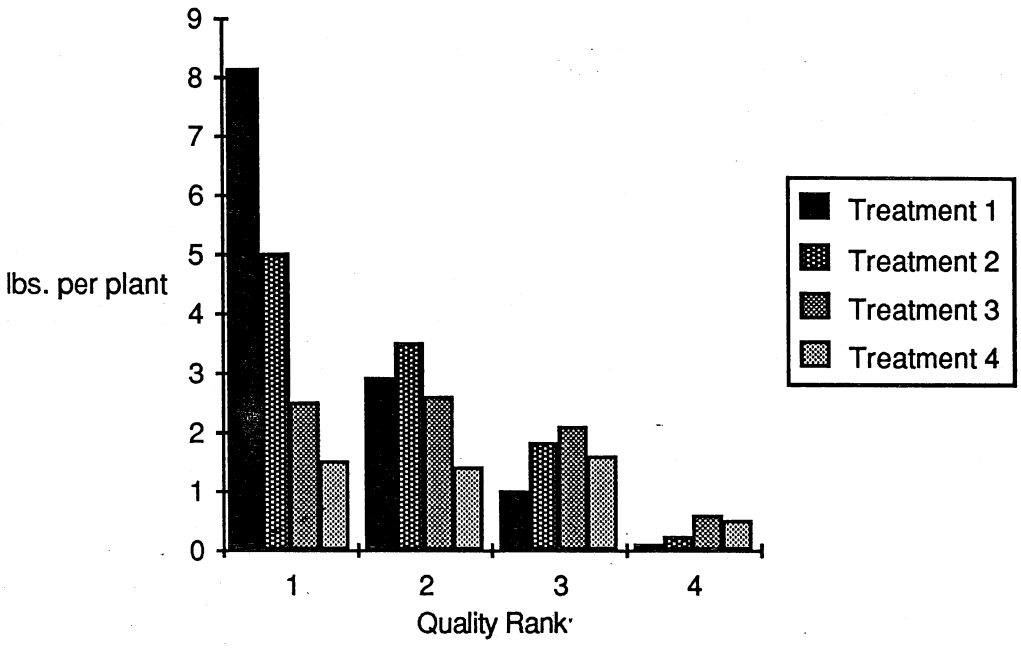
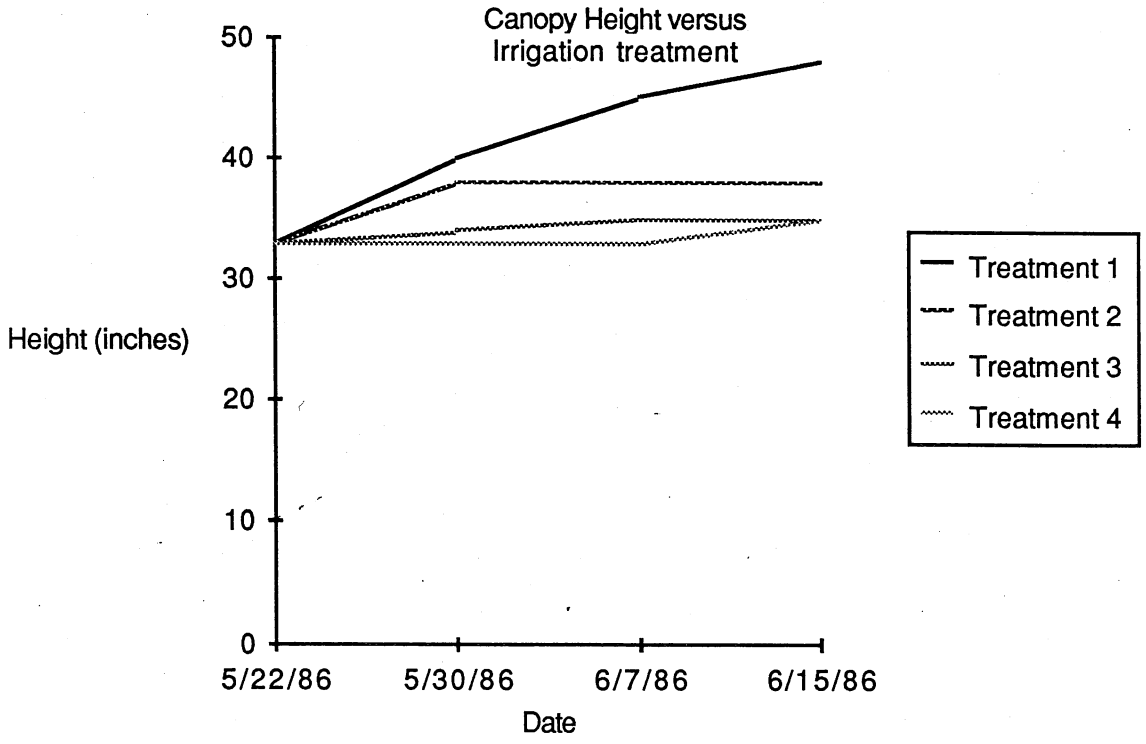
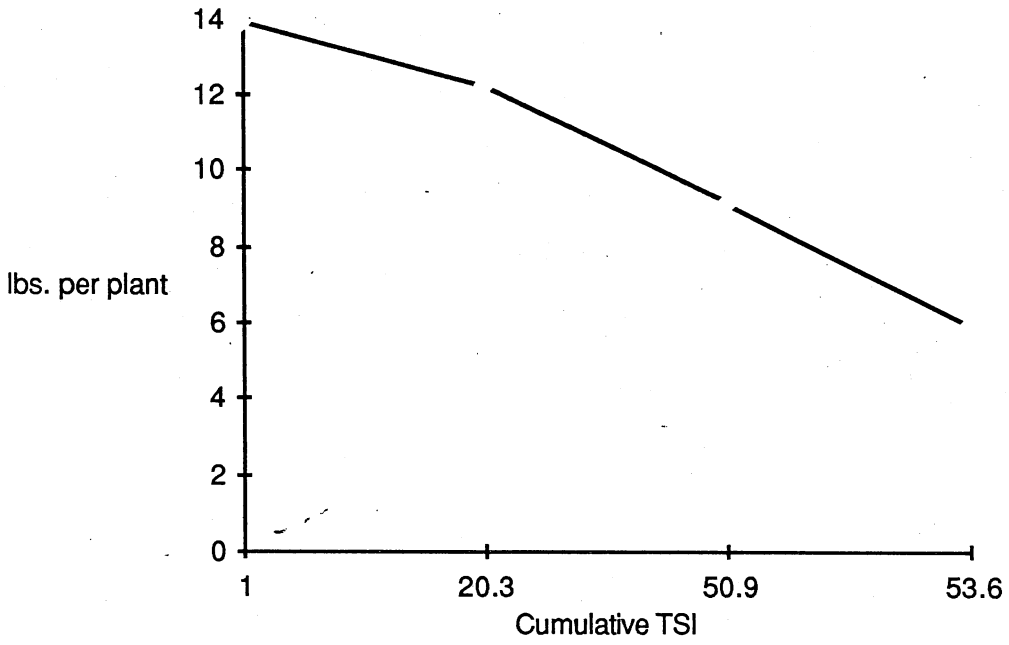

Alternate Stress Index
60
50
40
30
20
10
0
TSI
Treatment 3
Treatment 4
Treatment 2
Treatment 1
25 27 29 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Date
April
May

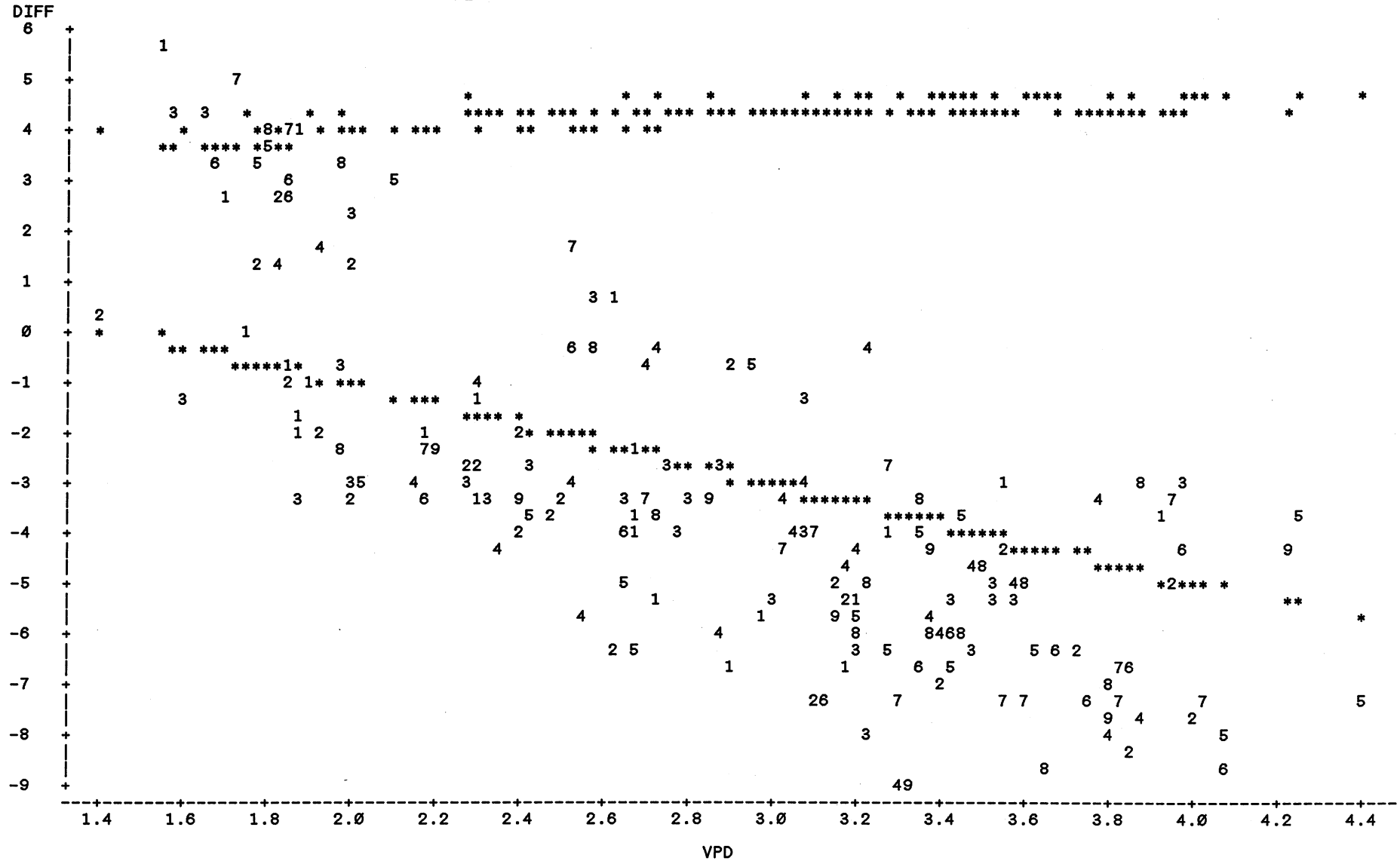

14
12
10
8
6
4
2
0
lbs./plant
1
2
3
4
Treatment


lbs. per plant
9
8
7
6
5
4
3
2
1
0
1
2
3
4
Quality Rank
Treatment 1
Treatment 2
Treatment 3
Treatment 4


Canopy Height versus
Irrigation treatment
Height (inches)
50
40
30
20
10
0
5/22/86
5/30/86
6/7/86
6/15/86
Date
Treatment 1
Treatment 2
Treatment 3
Treatment 4


14
12
10
8
6
4
2
0
lbs. per plant
1
20.3
50.9
53.6
Cumulative TSI

PLOT OF DIFF*VPD SYMBOL IS VALUE OF PLOT
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 158 OBS HIDDEN